Implementation - Predicting Moisture Induced Damage to Asphalt Concrete Design Mixes

Principal Investigator

Stephen Herzog

November 1981

Research Project 7926-04

This project was carried out in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the Montana Department of Highways or the Federal Highway Administration.

Technical Report Documentation Page

1. Report No.
FHWA MT-7926-04

2. Government Accession No.

3. Recipient's Catalog No.

4. Title and Subtitle
Implementation - Predicting Moisture Induced Damage to Asphaltic Concrete Design Mixes

5. Report Date
November, 1981

6. Performing Organization Code

7. Author(s)
Stephen L. Herzog

8. Performing Organization Report No.

9. Performing Organization Name and Address
Montana Department of Highways
Materials Bureau
2701 Prospect Avenue
Helena, MT 59620

10. Work Unit No. (TRAIS)

11. Contract or Grant No.

12. Sponsoring Agency Name and Address
U. S. Department of Transportation
FHWA
Offices of Research & Development
Washington, DC 20590

13. Type of Report and Period Covered
Final Report
1979-1981

14. Sponsoring Agency Code

15. Supplementary Notes
Technical Monitor, Robert T. Rask

16. Abstract
Six aggregate sources from around the State of Montana were selected to represent various qualities of aggregate and asphaltic concrete. Resilient ("R") Modulus tests, maximum tensile split tests and immersion compression tests were performed on each source and compared for correlation. Specimens used for the resilient modulus and the maximum tensile split tests were subjected to severe temperature conditioning, representing several years of natural exposure.

The resultant data indicates that the use of the maximum tensile split tests and the "R" modulus test are not appropriate for use on a routine basis. The Montana Department will continue to use the immersion compression test for moisture susceptibility prediction.

17. Key Words
Maximum Tensile Strength, Immersion Compression, "R" Modulus, Moisture Susceptibility, Asphaltic Concrete Mix Designs, Asphalt Concrete

18. Distribution Statement
No restrictions. This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)
Unclassified

20. Security Classif. (of this page)
Unclassified

21. No. of Pages

22. Price

Form DOT F 1700.7 (8-72)   Reproduction of completed page authorized

Acknowledgements

The support and direction given by Mr. Robert T. Rask both during the testing phase and report phase was extremely helpful.

A special note of appreciation goes to Mr. Jack O. Roberts for his assistance during the testing and data collection phase of this project.

Appreciation is also extended to the other members of the Materials Bureau who participated in this effort.

TABLE OF CONTENTS

Page

INTRODUCTION

This project is a result of previous research. The recommendations contained in FHWA MT 7926-02 "Predicting Moisture Induced Damaged to Asphalt Design Mixes" calls for the implementation of the maximum tensile split test. Prior to full implementation we are running this project as a pilot, attempting to further investigate the value of the maximum tensile split data. We are also looking at the possibility of utilizing the resilient modulus test data as an additional predictive tool.

Based on the problems involved with cracking and stripping in our roadways, the Montana Department of Highways is attempting to more accurately predict the effect moisture has on asphaltic concrete mixtures.

Currently, the immersion compression test is the critical test used to determine moisture susceptibility. The adhesion test and volume swell tests are also utilized in our evaluation. The purpose of this project is to evaluate the possible use of the maximum tensile split test and/or resilent modulus test data as additional tools in the prediction of the moisture susceptibility of asphalt cement mixtures.

We selected six aggregate sources from around the state that have a proven history and represent the various regional qualities of aggregate and asphaltic concrete throughout Montana. Twenty-four marshall size specimens were prepared from each source. Twelve specimen were prepared without any additives and twelve were prepared with additives. Each set of twelve was split into three groups of four. Each group was subjected to different environments. Four specimens were tested dry, four specimens were saturated in distilled water and four more specimens were saturated in distilled water and conditioned in a

freeze-thaw environment. Each group of dry, saturated and conditioned specimens were subjected to the same series of testing.

First, the specimens were subjected to a set of resilent modulus tests. One test was performed at a specimen temperature at 73°F and another test was performed at a specimen temperature of 55°F. Because the resilient modulus tests are non-destructive, a maximum tensile split test was also performed on each specimen at 55°F.

This data was all recorded and compared with immersion compression results. The immersion compression information used for comparison was gathered at the same time as the tensile split and resilient modulus information. The immersion compression specimens were fabricated using the same aggregate source and original mix design recommendations.

For a detailed description of the fabrication procedure for the 24 marshall type test specimens as well as the method utilized for the saturation and conditioning of these specimens, please refer to "The Working Plan and Guidelines for NCHRP 4-8(3)/1 - Field Evaluation Phase". The guidelines and procedures we used to perform the resilient modulus tests and maximum tensile split tests are also described in the NCHRP 4-8(3)/1 document. The immersion compression was performed according to AASHTO T-165. (Effect of Water on Cohesion of Compacted Bituminous Mixtures.)

When the data was compiled, the evaluation process began. There are three phases of the data interpretation. First, each source was evalualted for a relative correlation of the three tests, both with and without additives. The specimens were split, to observe visually what variation in stripping occurred and

to see if what occurred substantiated the test data. Finally, the data from each of the six sources was combined on two sheets. One sheet, Table 1, contains data for the six sources without additives and another, Table 2, contains the data for the six sources using additives. These sheets were then reviewed to identify any trends or outstanding correlation.

In comparing the various test results, the following table contains the range of average values expected in pounds per square inch based on previous experience with these tests:

Environment	"R" Modulus 73° ($x10^3$) (psi)	"R" Modulus 55° ($x10^3$) (psi)	Tensile Split (psi)	I.C. (psi)
Dry	150-300	800-1200	45-60	150-250
Saturated	100-200	400-900	40-45	125-175
Conditioned	75-150	300-700	30-40	---

For the "R" modulus and tensile split ratios we expect values in the range of 0.60 to 0.75 for saturated to dry ratios and a range of 0.40 to 0.50 for conditioned to dry ratios.

The minimum acceptable immersion compression retained strength ratio is 0.59.

The following six synopsis represent the initial data review, and visual observations:

DISCUSSION OF TEST RESULTS

Wibaux Co. Line West
I 94-6(26)216
Pit Lab. No. 515434-443
Loc. W1/2 SE1/4 Section 27, T-16-N, R-55-E
Materials Bureau recommendation 6.5% 120/150 Penetration Asphalt No Additive
Test Results Exhibits A & B

"R" Modulus No Additives:

Values of the dry specimens are in the midrange. The wet to dry ratio is also about average. The condition to dry ratio seems to indicate that under freeze thaw conditioning this mix is marginal.

Immersion Compression

The wet and dry break values fall in the average range. The retained strength ratio of .815 normally indicates a good source.

Tensile Split:

The dry tensile split values are likewise in the midrange. The saturated and conditioned values appear to be low. The ratio's of the wet to dry and condition to dry comparisons appear to correlate very well with the "R" modulus ratios.

Summary No Additives:

The comparison of the three tests appear to reinforce one another, with the exception of the immersion compression retained strength ratio. The immersion compression wet and dry break values seem to be comparable in terms of relative magnitude, to the "R" modulus and tensile split values.

The tests seem to indicate a fair aggregate which is not severely susceptible to moisture induced damage.

Wibaux Source With Additives:

"R" Modulus:

The values of both the wet and dry specimens increased significantly and appear to represent a good mix. The conditioned specimens increased more than double indicating quite a change using lime. The ratios of wet to dry and conditioned to dry appear to indicate an improvement in moisture susceptibility.

Immersion Compression:

The dry break strength increased 32% and the wet break strength increased 37% when compared to the specimens without lime. The average values of 223.2 psi for the dry breaks and 188.6 psi for the wet breaks represent values in the average range. The retained strength ratio of 84.5% coupled with the increases in both the wet and dry strengths would normally indicate the mix using hydrated lime is more resistant to moisture damage than was the initial mix.

Tensile Split:

The dry specimens' average with lime decreased while the wet and conditioned values increased. These increases in values suggests an increase, also, in the resistance to moisture damage. The wet to dry ratio and conditioned to dry ratio also indicate an increase in the moisture resistance.

Summary With Additives:

The comparison of the three tests generally correlate. However, the dry tensile split values are low initially which results in higher wet and conditioned ratios.

Wibaux - Visual Observation:

Very little difference is observed in the three sets of specimens containing lime. The original mix was discarded prior to observation. Only miniscule stripping was observed in the conditioned specimens. Otherwise, they all appear about the same, slightly rich in asphalt.

4th and 6th Ave. N. - Billings
M 1018(4)
Pit Lab. No. 529918-529922
Loc. SE1/4 of Section 18, T-1-N, R-27-E
Materials Bureau Recommendation: 4.75% 85/100 Penetration Asphalt No Additives
Test Results Exhibits C & D

"R" Modulus No Additives:

The "R" modulus values are all very good to excellent with the possible exception of the conditioned specimen at 73°F, which could be categoried in the above average range. The wet to dry ratios are good at both 73°F and 55°F while the condition to dry ratios seem to be low. This would indicate a mix which is not too moisture susceptible but may be suspect in a freeze-thaw condition.

Immersion Compression:

The dry and wet break values are a bit higher than average. The retained strength ratio of .73 would normally indicate an acceptable source.

Tensile Split:

The dry and wet values are in the very good to excellent range, while the conditioned values tend to be slightly low. The wet to dry ratio is quite good indicating a good resistance to moisture. On the other hand the conditioned to dry ratio seems to predict a good possibility of freeze-thaw susceptibility.

Summary No Additives:

The tests all seem to correlate quite well. The "R" modulus, immersion compression and tensile split test ratios are very consistent with one another. Based on the data one would normally conclude that this mix should

be quite resistant to moisture damage but could possibly be suspect in a freeze-thaw environment.

Billings Source With Additives:

"R" Modulus:

The values of the "R" modulus tests for the mix with lime are generally of the same order of magnitude as those for the mix without lime. The effects of the lime vary. For the dry "R" modulus the value increased at 73° and decrease in value at 55°. For the wet specimens the "R" modulus values both increased while for the conditioned specimens the values decreased. Also by comparing the ratios of the wet to dry and the conditioned to dry, the data seems to indicate that the addition of the lime did very little to enhance either the moisture resistance or the freeze-thaw susceptibility.

Immersion Compression:

The dry and wet break values are both in the very good to excellent range. The dry break value of 348.2 psi is an increase of 32% over the mix without lime. While the wet break value of 264.2 psi is an increase of 38%. The retained strength ratio of 0.759 plus the increase in break strengths, seems to indicate improvement in the mixes moisture resiliance when lime is added.

Tensile Split:

The values for the dry test ran above average but are lower than the dry tests without lime. The wet specimens tested very well and increased 20% over those specimens without lime. The conditioned specimens also decreased in strength with the addition of lime. Based on the tensile split test one would feel that the use of lime made the mix better relative to moisture

susceptibility and made a poor situation, worse in regards to the freeze-thaw resistance.

Summary With Additives:

The tests tend to compare favorably for the wet specimens and the conditioned group, but fail to lend any consistent results for the dry tests.

Billings Visual Observation:

No difference is observed in the relative amounts of stripping between the specimens with lime and those without lime for the sets of specimens subjected to the same environment. The saturated wet specimens appear drier than do the dry specimens, and the conditioned specimens appear to be the driest of all.

The specimens without lime appear rich in asphalt and also have more fractured aggregate exposed.

Only very minor stripping has taken place in the conditioned specimens. From the test data one would have expected more stripping in the conditioned specimens than was actually observed.

Prairie County Line East and West
IR 94-4(33)154
Pit Lab. No. 526213-526217
Loc. E1/2, SE1/4 Section 31, T-11-N, R-50-E
Materials Bureau Recommendation: 5.5% 120/150 Penetration Asphalt No Additives
Test Results Exhibits E & F

"R" Modulus No Additives:

The dry, wet and conditioned "R" modulus test results at 73° are all below average. The results of the tests at 55° are all on the low end of the average range expected. The ratios of the wet to dry and the conditioned to dry specimens fall toward the upper end of expected average values. From this data, it appears that our initial mix is possibly marginal in strength, making it seem to be less susceptible to moisture and freeze-thaw than it may actually be.

Immersion Compression:

The dry and wet break strengths are average. The retained strength ratio is very good and normally indicates a mix which isn't very susceptible to moisture damage.

Tensile Split:

In all cases the tensile split average values were either slightly below or on the low end. This seems to indicate a mix with mediocre strength. The wet to dry ratio and the conditioned to dry ratio indicates a relatively good resistance to moisture and freeze-thaw. When coupled with the low dry strength test value this may not be the case.

Summary No Additives:

The tests do not appear to correlate well, but in each test similar conclusions are drawn. It appears this mix is acceptable but not an extremely

good one. The data seems to suggest we have a mix with relatively low dry strengths that is modestly affected by moisture and freeze-thaw.

Prairie County Line Source With Additives:

"R" Modulus:

All the results of the "R" modulus tests are on the high side of average or above. Also, in each case using lime, there is a significant increase in values when compared to the results without lime. In addition, the wet to dry and the conditioned to dry ratios increased in value. All this indicates that the mix with lime has more strength and is much less susceptible to moisture and freeze-thaw.

Immersion Compression:

The dry break strength had no change when lime was added and the wet break only increased 15%. The retained strength ratio of .951 is excellent. With the values in the midrange and with a good retained strength ratio, it appears the mix with lime is slightly better than the mix without lime.

Tensile Split:

With the addition of lime, all of the tensile split average values fall above average or in the upper end of the average range. The ratios are also very good. This data seems to indicate a mix with very good strength, that is moisture resistant and should perform well in a freeze-thaw environment.

Summary With Additives:

The conclusion drawn on each test generally compliment one another except for the immersion compression tests results. The immersion compression values were not as affected by the addition of lime as were the other

results. For the most part, the tests all indicated the mix was much better with lime from the standpoint of increased strength, increased resistance to moisture and freeze-thaw.

Prairie County Line North Visual Observation:

Visually there was very little difference between the specimens. The dry specimens with and without lime did appear a bit richer than did the saturated and the conditioned specimens. Otherwise, the only visual difference observed was the conditioned specimens without lime were beginning to strip to very minor degree.

Based on the test data from resilient modulus and tensile split you would have expected more stripping but the immersion compression suggests otherwise, which appears to be the case.

Toole County Line North
I 15-8(37)343
Pit Lab. No. 448559-61 and 513191-95 and 321849-875
Loc. SE1/4 Section 28 and SW1/4 Section 27, T-31-N, R-2-W
Materials Bureau Recommendation: 5.5% 120/150 Penetration Asphalt 1.5% Fly Ash
Test Results Exhibits G & H

"R" Modulus No Fillers:

All of the "R" modulus test results fall into the average range. The wet to dry ratios are good which indicates the mix shouldn't be affected by moisture. The conditioned to dry ratio is low indicating the possibility of damage in a freeze-thaw environment.

Immersion Compression:

The tests results seem to be better than average. This coupled with a retained strength ratio of .71 seem to indicate the mix shouldn't be susceptible to moisture damage.

Tensile Split:

The tensile split test values for the dry and wet specimens are all very good but the conditioned specimens are low. The wet to dry ratio and the conditioned to dry ratio follow the same pattern.

The wet to dry ratio is quite good and the conditioned to dry ratio is poor. This data indicates that the mix should not be very susceptible to moisture damage but is likely to experience damage in a freeze-thaw environment.

Summary No Fillers:

The test results all correlate very well. Each set of test data seem to indicate the same thing. This mix should not be very susceptible to moisture damage but has a good possibility of experiencing some damage in a freeze-thaw environment.

Toole County Line with Fly Ash:

"R" Modulus:

The addition of fly ash to the mix causes the values to increase slightly for the dry specimens, modestly for the wet specimens and significantly for the conditioned samples. The wet to dry ratios show a modest increase while the conditioned to dry ratio show a significant rise. The results indicate, that the addition of fly ash will modestly improve the mix, which is good in a dry and wet environment, while at the same time, significantly improve the mixes performance in a freeze-thaw environment.

Immersion Compression:

The test results are better than average and show a slight increase over the dry and wet breaks of those specimens without fly ash. The retained strength ratio of .80 shows a slight increase over the immersion compression specimens without fly ash. Such results indicate a slight increase in the mix's ability to resist moisture damage.

Tensile Split:

Adding fly ash to the mix appears to have caused the dry tensile split strength to decrease, the wet tensile strength to remain the same and the conditioned specimen strength to increase appreciably.

The wet to dry ratio is very good, normally signifying a mix which is quite resistant to moisture. The condition to dry ratio is reasonable. Consequently, the mix with fly ash is still susceptible to freeze-thaw damage but not nearly as much so as the mix without fly ash.

Summary With Fly Ash:

It appears that the test results compare extremely well in all phases of testing performed on this source. The ratios all compare well and the conclusions drawn, based on each set of tests, seem to verify one another. Using fly ash generally appears to enhance the mix's performance in both moisture and freeze-thaw environments.

Toole County Visual Observation:

The dry specimens with and without fly ash show no stripping and each appears to have the same coating. The saturated wet specimens without fly ash show a slight degree of stripping, and so do the specimens with fly ash. But, the specimens containing fly ash have not stripped to the same degree, as the saturated wet specimens without fly ash.

There is a considerable difference in the amount of stripping which has occurred between the conditioned specimens with fly ash and those specimens without. The specimens without fly ash have shown moderate to severe stripping, while the specimens with fly ash were only moderately stripped.

None of the test values seem to predict the severity with which moisture and conditioning have affected the specimens in this mix design.

Sieben - Wolf Creek
I 15-4(51)217 and IR 15-4(53)218
Pit Lab. No. 534227-30
Loc. S1/2 NW1/4 Section 11, T-14-N, R-4-W
Materials Bureau Recommendation: 6.0% 120/150 Penetration Asphalt 1.5% Hyd. Lime
Test Results Exhibits J & K

"R" Modulus Without Additives:

The dry and wet "R" modulus test values all fall on the high side of the average range and in some cases above average. The wet to dry ratios vary. Looking at the ratio at 73°, the mix seems to be very good but the 55° ratio is only fair. This variance seems to indicate the ability to resist moisture may be questionable. The conditioned specimens results ran quite low as did the conditioned to dry ratios. Such results seem to indicate that there is a high probability this mix is quite susceptible to damage in a freeze-thaw environment.

Immersion Compression:

The dry strength was excellent but the wet strength was very poor. Consequently, the retained strength ratio was very low at .25. This indicates a mix which is highly susceptible to moisture damage.

Tensile Split Test:

The dry specimen results are well above average. The wet specimens are also above average but not to the same degree as the dry specimens. Conversely, the conditioned specimen results are below average. As a result, the wet to dry ratio and conditioned to dry ratios are fair and poor respectively. This test data seems to suggest that the mix has a good probability of incurring moisture damage and is highly susceptible to freeze-thaw.

Summary:

This set of test data shows the three tests coming to similar conclusions but the test results are not consistently compatible. The dry test data has good "R" modulus results and the dry tensile split average is also high. The saturated specimens compare well at 55° but the ratio at 73° is higher. The immersion compression results would normally discredit this mix. The tensile split and "R" modulus tests, also indicate a poor mix, in an environment where there is freeze-thaw.

Sieben Wolf Creek With Additives:

"R" Modulus Test:

The dry "R" modulus test performed at 73° increased modestly while the dry "R" modulus at 55° and the saturated "R" modulus tests increased slightly with the addition of lime. The test values are generally above average. The conditioned specimens showed a dramatic increase in test values with the addition of lime. Although the results for both sets of test data increased, the tests at 73° seem to have been affected to a greater degree with the addition of lime. The wet to dry ratio and the conditioned to dry ratios all ran about the same. A ratio of .63 for saturated specimens generally seems to indicate there may be a moisture susceptibility problem. Conversely, a value of .65 for a conditioned to dry ratio seems to indicate that a specimen isn't too bad relative to freeze-thaw.

Immersion Compression:

The dry break strength increased slightly to 333.4 psi which is excellent. The wet break strength increased well over double from a poor 81.2 psi to a very good 186.2 psi. The retained strength ratio is .56, which is normally

indicative of a mix that is modestly susceptible to moisture.

Tensile Split:

The dry tensile split strength remained unchanged with the addition of lime, while the saturated strength test value increased only slightly. Looking at the conditioned tensile split test results, you see a significant increase, to above average levels. The wet to dry ratio with lime is .69 which is good. This indicates the mix is only slightly susceptible to moisture. The conditioned to dry ratio is .59. Considering that the test values for the dry tensile split test are well above average and the conditioned values are also above average, the mix probably won't be too susceptible to freeze-thaw damage.

Summary With Additives:

For the most part all of the tests correlate quite well. Basically, the mix's susceptibility to moisture and freeze-thaw is enhanced by the addition of lime. This degree of enhancement is a bit speculative but seems to be significant.

Sieben-Wolf Creek Visual Observation:

The dry specimens with and without lime are visually identical, relative to stripping and color. This is pretty consistent with the calculated results which varied little. The saturated specimens also appear quite similar which the test results verify. Looking at the conditioned specimens, the samples with lime appear visually, in better condition than the specimens without lime. The specimens without lime appear to have been more severely affected by the freeze-thaw environment.

Overall, the tests seem to verify what visually appears to be happening. The dry and saturated mix design specimens were unaffected by the addition of lime. For the conditioned specimens, the addition of lime enhanced the performance of the mix significantly test-wise and also visually. The freeze-thaw conditioning had stripped the specimens without lime to a greater degree than those specimens with lime.

Fairfield East and West (N. Section)
F-3(2)23
Pit Lab. No. 373880-890
Loc. NW1/4 Section 27, T-22-N, R-3-W
Materials Bureau Recommendation - 6% 120/150 Penetration Asphalt 1.5% Hyd. Lime
Test Results Exhibit L & M

"R" Modulus No Additives:

The average test values all fall in the midrange of expectation. The wet to dry ratio is very good and seems to represent a fairly good mix which should be quite resistant to moisture. Looking at the conditioned to dry ratios, which are not too outstanding, you could expect this mix design to be somewhat susceptible to damage from freeze-thaw.

Tensile Split:

The values for the dry and wet tensile split tests, fall in the upper end of the average range. The wet to dry ratio is very good which could mean this mix shouldn't be affected much by moisture. The conditioned specimen's results are low and the conditioned to dry ratio is marginal. This would seem to indicate a mix with possible freeze-thaw susceptibility.

Immersion Compression:

The dry break strengths were very high and the wet break strengths were quite low. The retained strength ratio of .38 normally indicates a mix which is very susceptible to moisture damage.

Summary No Additives:

The tensile split tests and "R" modulus tests correlate very well. Both sets of data seem to indicate the mix is fairly good in a wet and dry environment but is probably susceptible to freeze-thaw damage. The immer-

sion compression test results normally indicate a mix with high susceptibility to moisture.

Fairfield Source With Addivites:

"R" Modulus:

The wet and dry "R" modulus test values increase. Those tests performed at 73°F increased much more than did the results for the test performed at 55°. Looking at the test data, the results still fall within the midrange. The results of the conditioned specimens showed a greater impact on the results using lime. The tests values moved from below average to the upper end of average or above. From this data it would appear that the use of lime would cause the mix to be slightly more resistent to moisture and much more resistant to a freeze-thaw environment.

Tensile Split:

Adding lime to the mix, caused both the dry and wet test results to increase to above average levels. The wet to dry ratio stayed about the same, signifying a uniform increase in strength in both cases. This data would support the idea that adding lime enhanced the moisture resistance of the mix. The conditioned specimens test results, also increased with the addition of lime to the mix. The impact of lime is much more pronounced for the conditioned specimens than it was for the dry and saturated specimens. The test results for the conditioned specimens without lime were below average, where the test results for specimens with lime are well into the average range. The conditioned to dry ratio also improved. This along with the increased conditioned tensile split average seems to indicate, the mix with lime is more resistant to damage in a freeze-thaw environment.

Immersion Compression:

The dry values increased to 414.6 psi using lime which is an increase of 20%. The wet break strength increased 130% to 304.8 psi. Correspondingly, the retained strength ratio increased from .38 to .74. Normally, this would support the use of lime to enhance the mix making it more resistant to moisture.

Summary With Additives:

The tensile split and "R" modulus test results correlate extremely well. Both sets of data seem to suggest that the addition of lime enhances the performance of the mix in dry and wet environments and enhances the performance in freeze-thaw significantly. With the lime, we should expect a mix with very little susceptibility to moisture and freeze-thaw.

Fairfield Source Visual Observation:

In each case, the set of specimens with lime appears to be a bit drier. There doesn't seem to be any significant difference in appearance relative to stripping. In fact, one needs to look quite closely to find the minor stripping which has taken place in the conditioned specimens without lime. Also, in all cases there was a great deal of aggregate fracture apparent.

The dry and saturated test data seem to support the visual observation. However, based on the immersion compression results and the conditioned specimen test data, for the specimens without lime, it would have been reasonable to expect more stripping than was observed in the conditioned specimens without lime.

GENERAL COMMENTS AND CONCLUSION

For this report, we are assuming that the immersion compression test procedure and results are the established standard for comparison. The initial goal was to evaluate the possibility of utilizing the tensile split test and/or resilient modulus test data in conjunction with the immersion compression data to more accurately predict the moisture susceptibility of an asphalt concrete mix design.

Key comparisons between immersion compression and resilient modulus and immersion compression and tensile split are graphed to illustrate their relative correlation (See pages 40-44). Also, graphed are two relationships between stripping and immersion compression (See page 45).

Table 3 contains a list of all the comparisons made and their correlation coefficients. To be 95% confident that there is a correlation, a coefficient of correlation of .81 is needed.

At this point in our research, it does not appear that there is enough correlation or consistency in our test results to substantiate the possibility of using either the tensile split or resilient modulus tests.

Further discussion of specific comparisons between tables 1 and 2 follows, along with our recommendations.

As a final comparison, the data gathered on all the tests is compiled in two tables. Table 1 has the average test values for all six sources using no fillers or additives. Table 2 is the same, only this data is based on the results of mixtures using fillers or additives.

For example, looking at Table 1 and comparing the dry tensile split test values

to the dry immersion compression test values, you observe significant inconsistencies. The Wibaux source had a tensile split value of 54.3 psi which is of similar magnitude as the Fairfield value of 57.9 psi. Comparing then, the Wibaux dry IC break strength value of 168.9 psi to the Fairfield value of 346.2 psi one must question the test results as indicators. Likewise, the similarity of inconsistency can be seen by comparing Sieben - Wolf Creek's IC dry break of 324.7 psi to Fairfield's 346.2 psi which corresponds to a tensile split of 87.8 psi for Sieben - Wolf Creek versus the Fairfield tensile split value of 57.9 psi.

Now, if one assumes the Fairfield data is erroneous or didn't apply, there is a semblance of correlation with the balance of dry IC break values and the dry tensile split values, until you look at Table 2. Looking at the Billings dry tensile split average value of 57.2 psi and comparing it to a Prairie County value of 56.6 psi in Table 2 we find corresponding dry IC break values of 348.2 psi and 179.1 psi respectively. Again, there is no good correlation, and little is apparent in the comparison of dry IC and dry tensile split test results for the sources in Table 2.

Doing a similar comparison of the saturated tensile split test values as compared to wet immersion compression test values yields similar results. In Table 1 the wet break IC values for Wibaux and Fairfield are 137.7 psi and 131.7 psi respectively. Those values correspond to tensile split values of 31.4 psi for Wibaux and 50.5 psi for Fairfield, which don't correlate too well. Likewise, in the comparison of Toole County and Sieben - Wolf Creek, where a saturated tensile split value of 57.6 psi corresponding to a value of 55.7 psi does not correlate with the wet IC break values of 191.1 psi for Toole County and 81.2 psi for Sieben - Wolf Creek.

Further investigation, comparing tensile split ratios to IC retention strength ratios also does little to substantiate any correlation between the two tests.

Looking at the resilient modulus test as compared to immersion compression consider the Billings source and Toole County source in Table 1. For all practical purposes, the immersion compression data is the same for these two sources. Now, comparing the resilient modulus test data you have different orders of magnitude but the ratios are comparable. Further comparisons of immersion compression data and resilient modulus data continue to raise questions. The dry immersion compression break strength for Billings in Table 1 ranks fourth in magnitude while the resilient modulus dry strength at 73° and 55° are the highest. While, the wet immersion compression break strength for Billings is the highest as are the saturated and conditioned resilient modulus values in Table 1.

Looking at Table 2, the Fairfield source has the highest wet and dry immersion compression break strength, but the resilient modulus values are third, fourth and fifth by comparison. There are also other inconsistencies in Table 2 which make it difficult to detect any significant consistent correlation between immersion compression test data and resilient modulus data.

Finally, we looked at how the tensile data and the resilient modulus data compared. The relative magnitudes of the test values and ratios show a fairly good correlation when the two test methods are compared within the same environment; such as, dry, saturated and conditioned. Right now we do not know of what value this correlation is or could be.

Looking at the tensile split test values for the conditioned specimens without fillers, it appears the conditioning process may be too severe. There is very

little variation in the results indicating the conditioning environment was probably too harsh.

In comparing the test results on each source we found the "R" modulus, tensile split and immersion compression tests had more correlation than did the comparisons of the specific test results between the six sources.

In summary, the data gathered from the six selected sources, does not substantiate or suggest the use of the tensile split test or resilient modulus test as viable alternatives or tools in the prediction of moisture susceptibility for asphalt concrete mix design.

RECOMMENDATIONS:

1. Do not implement or incorporate a moisture prediction program for asphalt cement which relies on tensile split test data and/or resilient modulus test data at this time.

2. Continue to rely on the immersion compression results as the key criteria in moisture susceptibility prediction in asphalt concrete design mixes.

3. Because of the added information gained in a conditioning process, using freeze-thaw, a less severe test should be developed for any future "R" modulus or tensile split research, and should be investigated for use in the immersion compression procedure.

4. Consider research into how aggregate fracture and absorption affect tensile split and resilient modulus tests.

5. Study a single source of known good aggregate and vary asphalt contents, additives, to determine the effects on tensile split and resilient modulus test values.

EXHIBIT A

7926-04

Wibaux Source
No Additives

	Core	Dry Mr 73 (psi)	Dry Mr 55 (psi)	Dry Tensile Split (psi)	Sat Mr 73 (psi)	Sat Mr 55 (psi)	Sat Tensile Split (psi)
Dry	1	182,567	759,430	58.7			
	2	145,914	752.620	51.6			
	6	150,339	801,984	57.5			
	10	140,002	705,442	49.3			
	AVG	154,706	754,869	54.3			
Sat	3				105,959	476,328	32.7
	4				66,680	324,589	28.6
	8				108,078	432,168	29.0
	9				96,122	437,602	35.2
				Average	94,210	417,671	31.4
				Ratio Sat/Dry	.61	.55	.58
Cond	5				70,679	281,546	23.1
	7				75,326	321,193	24.2
	11				63,727	241,614	20.3
	12				77,470	281,051	23.7
				Average	71,801	281,351	22.8
				Ratio Cond/Dry	.46	.37	.42

Immersion Compression Data
Avg. dry break strength 168.9 psi
Avg. wet break strength 137.7 psi
Retained strength ratio = 81.5%

EXHIBIT B

7926-04

Wibaux Source
With Hydrated Lime

	Core	Dry Mr 73 (psi)	Dry Mr 55 (psi)	Dry Tensile Split (psi)	Sat Mr 73 (psi)	Sat Mr 55 (psi)	Sat Tensile Split (psi)
Dry	1	211,488	870,625	46.5			
	2	196,987	895,213	43.5			
	6	222,396	978,858	47.9			
	10	192,712	972,601	40.1			
	AVG	205,896	929,324	44.5			
Sat	3				165,145	835,970	38.5
	4				138,232	726,329	32.9
	8				147,208	702,445	35.5
	9				177,255	741,822	42.1
				Average	156,960	751,642	37.3
				Ratio Sat/Dry	.76	.81	.84
Cond	5				136,444	737,137	32.6
	7				119,909	624,885	31.8
	11				185,884	814,942	37.2
	12				215,088	920,441	38.0
				Average	164,331	774,351	34.9
				Ratio Cond/Dry	.80	.83	.78

Immersion Compression
Dry Break Strength 223.2 psi
Wet Break Strength 188.6 psi
Retained Strength Ratio 84.5%

Billings Source
No Additives

	Core	Dry Mr 73 (psi)	Dry Mr 55 (psi)	Dry Tensile Split (psi)	Sat Mr 73 (psi)	Sat Mr 55 (psi)	Sat Tensile Split (psi)
Dry	4	370,846	1,611,577	72.2			
	5	385,689	1,984,923	67.2			
	9	331,483	1,628,419	76.9			
	12	323,995	1,433,832	64.9			
	AVG	353,008	1,664,688	70.3			
Sat	2				315,146	1,169,895	51.5
	7				261,256	1,120,388	40.3
	10				261,128	1,325,491	47.3
	11				287,726	1,052,393	51.0
				Average	281,314	1,167,042	50.0
				Ratio Sat/Dry	.80	.70	.71
Cond	1				147,205	796,869	36.0
	3				81,651	469,589	24.6
	6				77,346	408,275	17.9
	8				128,536	635,948	25.4
				Average	108,685	577,625	26.0
				Ratio Cond/Dry	.31	.35	.37

Immersion Compression
Dry Break Strength 262.6 psi
Wet Break Strength 191.4 psi
Retained Strength Ratio 73%

EXHIBIT D

7926-04

Billings Source
With Hydrated Lime

	Core	Dry Mr 73 (psi)	Dry Mr 55 (psi)	Dry Tensile Split (psi)	Sat Mr 73 (psi)	Sat Mr 55 (psi)	Sat Tensile Split (psi)
Dry	4	554,063	1,295,993	64.1			
	5	539,072	1,220,283	62.1			
	9	437,854	1,215,341	54.7			
	12	526,697	1,583,436	47.9			
	AVG	514,422	1,328,763	57.2			
Sat	2				365,964	1,074,054	58.5
	7				407,204	1,284,582	58.8
	10				457,011	1,212,156	56.1
	11				420,563	1,367,279	70.0
				Average	412,686	1,234,517	60.9
				Ratio $\frac{\text{Wet}}{\text{Dry}}$	.80	.93	1.06
Cond	1				119,949	543,961	24.8
	3				116,508	647,154	25.1
	6				100,915	467,147	25.7
	8				91,998	384,079	20.5
				Average	107,343	508,335	24.0
				Ratio $\frac{\text{Cond}}{\text{Dry}}$	.21	.38	.42

Immersion Compression
Dry Break Strength 348.2 psi
Wet Break Strength 264.2 psi
Retained Strength Ratio 75.9%

EXHIBIT E

7926-04

Prairie County Line North
No Additives

	Core	Dry Mr 73 (psi)	Dry Mr 55 (psi)	Dry Tensile Split (psi)	Sat Mr 73 (psi)	Sat Mr 55 (psi)	Sat Tensile Split (psi)
Dry	3	117,815	762,369	42.1			
Dry	6	135,941	806,279	45.9			
Dry	9	150,553	896,321	51.4			
Dry	10	153,867	926,618	51.5			
	AVG	139,544	847,897	47.7			
Sat	1				54,973	339,924	28.3
Sat	4				57,331	369,277	33.6
Sat	5				107,422	582,265	45.2
Sat	11				78,790	521,929	32.5
				Average	74,629	453,349	34.9
				Ratio Sat/Dry	.53	.53	.73
Cond	2				52,163	372,450	-----
Cond	7				58,220	402,790	28.4
Cond	8				54,795	413,492	30.8
Cond	12				51,304	336,181	29.7
				Average	54,121	381,228	29.6
				Ratio Cond/Dry	.39	.45	.62

Immersion Compression
Dry Break Strength 179.0 psi
Wet Break Strength 148.0 psi
Retained Strength Ratio 83%

Prairie County Line No.
With Hydrated Lime

	Core	Dry Mr 73 (psi)	Dry Mr 55 (psi)	Dry Tensile Split (psi)	Sat Mr 73 (psi)	Sat Mr 55 (psi)	Sat Tensile Split (psi)
Dry	3	249,223	1,178,129	56.0			
Dry	6	234,267	1,290,144	54.8			
Dry	9	260,947	1,181,444	52.2			
Dry	10	257,323	1,321,857	63.2			
	AVG	250,440	1,242,894	56.6			
Wet	1				168,542	1,115,800	52.9
Wet	4				165,976	1,090,603	55.8
Wet	5				185,374	881,979	52.9
Wet	11				188,203	915,767	54.1
				Average	177,024	1,001,037	53.9
				Ratio Sat/Dry	.71	.81	.92
Cond	2				120,203	691,101	46.9
Cond	7				119,353	775,160	43.8
Cond	8				134,234	826,765	46.2
Cond	12				136,157	762,676	40.9
				Average	127,487	763,926	44.5
				Ratio Cond/Dry	.51	.61	.79

Immersion Compression
Dry Break Strength 179.1 psi
Wet Break Strength 170.3 psi
Retained Strength Ratio 95.1%

Toole County Line No.
No Filler

	Core	Dry Mr 73 (psi)	Dry Mr 55 (psi)	Dry Tensile Split (psi)	Sat Mr 73 (psi)	Sat Mr 55 (psi)	Sat Tensile Split (psi)
Dry	3	228,042	891,168	64.8			
Dry	4	232,793	983,544	72.8			
Dry	8	221,206	928,530	62.7			
Dry	9	217,371	980,137	65.2			
	AVG	224,853	945,845	66.4			
Sat	2				200,074	728,875	62.8
Sat	5				200,429	784,120	61.1
Sat	7				182,839	759,580	56.2
Sat	12				157,962	689,521	50.2
				Average	185,326	740,524	57.6
				Ratio Sat/Dry	.82	.78	.87
Cond	1				105,147	401,387	30.9
Cond	6				80,959	307,342	19.5
Cond	10				100,470	398,636	24.7
Cond	11				94,909	385,761	30.7
				Average	95,371	373,282	26.5
				Ratio Cond/Dry	.42	.39	.40

Immersion Compression
Dry Break Strength 269.9 psi
Wet Break Strength 191.1 psi
Retained Strength Ratio 71.0%

Toole County Line No.
With Fly Ash

	Core	Dry Mr 73 (psi)	Dry Mr 55 (psi)	Dry Tensile Split (psi)	Sat Mr 73 (psi)	Sat Mr 55 (psi)	Sat Tensile Split (psi)
Dry	1	244,406	959,192	60.6			
Dry	2	289,084	1,019,432	59.0			
Dry	5	262,309	973,846	64.7			
Dry	9	236,183	882,464	63.9			
	AVG	257,996	958,734	62.1			
Sat	4				222,882	783,351	59.2
Sat	6				230,793	875,579	51.6
Sat	8				262,741	943,468	64.5
Sat	12				199,101	876,167	56.6
				Average	228,879	869,641	58.0
				Ratio Sat/Dry	.89	.91	.93
Cond	3				246,542	833,561	44.2
Cond	7				162,054	629,047	43.6
Cond	10				137,214	590,916	46.6
Cond	11				157,798	608,901	36.1
				Average	175,902	665,606	42.6
				Ratio Cond/Dry	.68	.69	.68

Immersion Compression
Dry Break Strength 279.5 psi
Wet Break Strength 224.5 psi
Retained Strength Ratio 80%

Sieben-Wolf Creek
No Additives

	Core	Dry Mr 73 (psi)	Dry Mr 55 (psi)	Dry Tensile Split (psi)	Sat Mr 73 (psi)	Sat Mr 55 (psi)	Sat Tensile Split (psi)
Dry	3	281,367	911,256	85.4			
	6	269,283	1,086,807	94.6			
	8	297,918	1,008,812	86.2			
	10	259,389	972,288	84.8			
	AVG	276,989	994,791	87.8			
Sat	1				224,892	675,845	56.1
	2				224,514	631,033	53.4
	9				242,406	640,261	57.5
	11				216,333	626,842	55.6
				Average	227,036	643,495	55.7
				Ratio Sat/Dry	.82	.65	.63
Cond	4				40,371	172,824	20.3
	5				67,908	318,194	25.8
	7				81,214	330,914	30.2
	12				60,633	285,175	21.7
				Average	62,532	276,777	24.5
				Ratio Cond/Dry	.23	.28	.28

Immersion Compression
Dry Break Strength 324.7 psi
Wet Break Strength 81.2 psi
Retained Strength Ratio 25.0%

Sieben-Wolf Creek
With Hydrated Lime

	Core	Dry Mr 73 (psi)	Dry Mr 55 (psi)	Dry Tensile Split (psi)	Sat Mr 73 (psi)	Sat Mr 55 (psi)	Sat Tensile Split (psi)
Dry	13	382,386	1,176,075	94.6			
Dry	15	384,031	1,023,807	79.3			
Dry	16	434,323	1,265,620	94.1			
Dry	24	389,197	1,140,822	82.6			
	AVG	397,484	1,151,581	87.7			
Sat	14				283,914	811,251	63.6
Sat	18				281,307	670,677	54.9
Sat	21				257,323	679,248	65.3
Sat	23				211,691	638,403	57.6
				Average	258,559	699,895	60.4
				Ratio Sat/Dry	.65	.61	.69
Cond	17				299,309	812,383	59.3
Cond	19				191,745	624,910	43.7
Cond	20				264,748	767,048	53.10
Cond	22				289,953	750,347	51.6
				Average	261,439	738,540	51.9
				Ratio Cond/Dry	.66	.64	.59

Immersion Compression
Dry Break Strength 333.4 psi
Wet Break Strength 186.2 psi
Retained Strength Ratio 55.8%

Fairfield Source
No Additives

	Core	Dry Mr 73 (psi)	Dry Mr 55 (psi)	Dry Tensile Split (psi)	Sat Mr 73 (psi)	Sat Mr 55 (psi)	Sat Tensile Split (psi)
Dry	13	171,359	773,824	55.9			
Dry	18	187,229	820,598	60.9			
Dry	19	185,627	953,392	58.7			
Dry	22	204,781	852,091	56.0			
	AVG	187,249	849,976	57.9			
Sat	17				160,798	785,798	49.0
Sat	20				154,117	671,874	51.4
Sat	23				169,540	736,047	52.4
Sat	24				174,791	699,762	49.3
				Average	164,812	723,370	50.5
				Ratio Sat/Dry	.88	.85	.87
Cond	14				-------	301,522	23.6
Cond	15				94,994	490,630	33.0
Cond	16				92,264	441,081	25.9
Cond	21				74,735	323,525	22.2
				Average	87,221	389,190	26.2
				Ratio Cond/Dry	.47	.46	.45

Immersion Compression
Dry Break Strength 346.2 psi
Wet Break Strength 131.7 pso
Retained Strength Ratio 38.0%

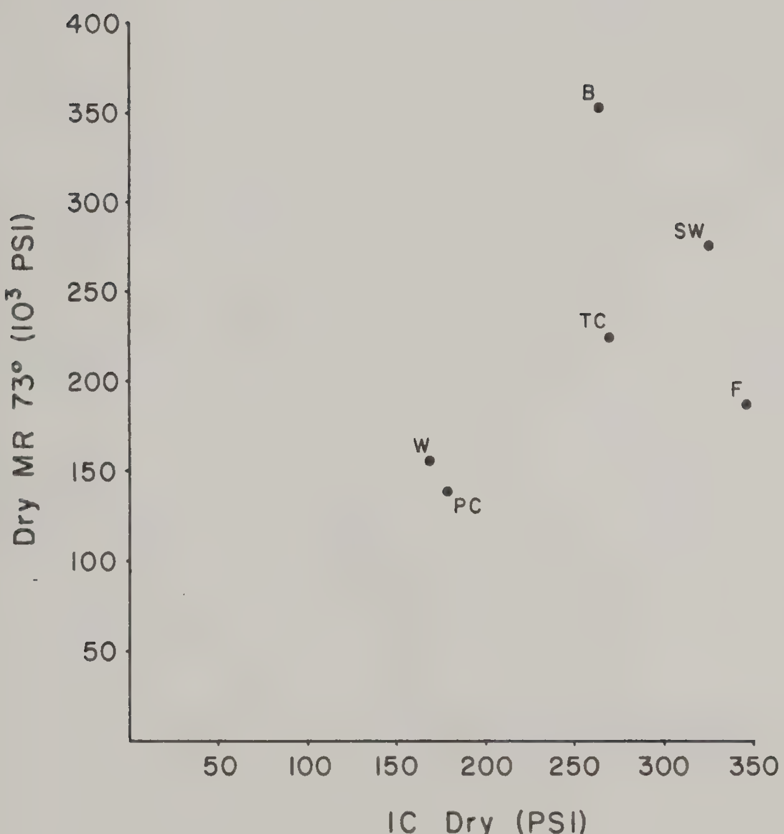
Fairfield Source
With Hydrated Lime

	Core	Dry Mr 73 (psi)	Dry Mr 55 (psi)	Dry Tensile Split (psi)	Sat Mr 73 (psi)	Sat Mr 55 (psi)	Sat Tensile Split (psi)
Dry	1	243,258	957,625	63.7			
	2	306,790	988,993	73.5			
	3	251,452	907,992	65.2			
	8	279,089	925,730	61.3			
	AVG	270,147	945,085	65.9			
Sat	6				280,212	822,838	57.4
	7				219,727	777,147	56.2
	10				229,809	798,523	61.7
	12				226,796	751,619	57.5
				Average	239,136	787,532	58.2
				Ratio Sat/Dry	.88	.83	.88
Cond	4				162,778	614,928	43.6
	5				199,133	807,732	44.0
	9				98,712	432,994	32.7
	11				181,448	611,832	38.0
				Average	160,518	616,872	39.6
				Ratio Cond/Dry	.59	.65	.60

Immersion Compression
Dry Break Strength 414.6 psi
Wet Break Strength 304.8 psi
Retained Strength Ratio 73.5%

	y	x
	MR Dry (73°)	IC Dry
W	154,706	168.9
B	353,008	262.2
PC	139,544	179.0
TC	224,853	269.9
SW	276,989	324.7
F	187,249	346.2

r=.46

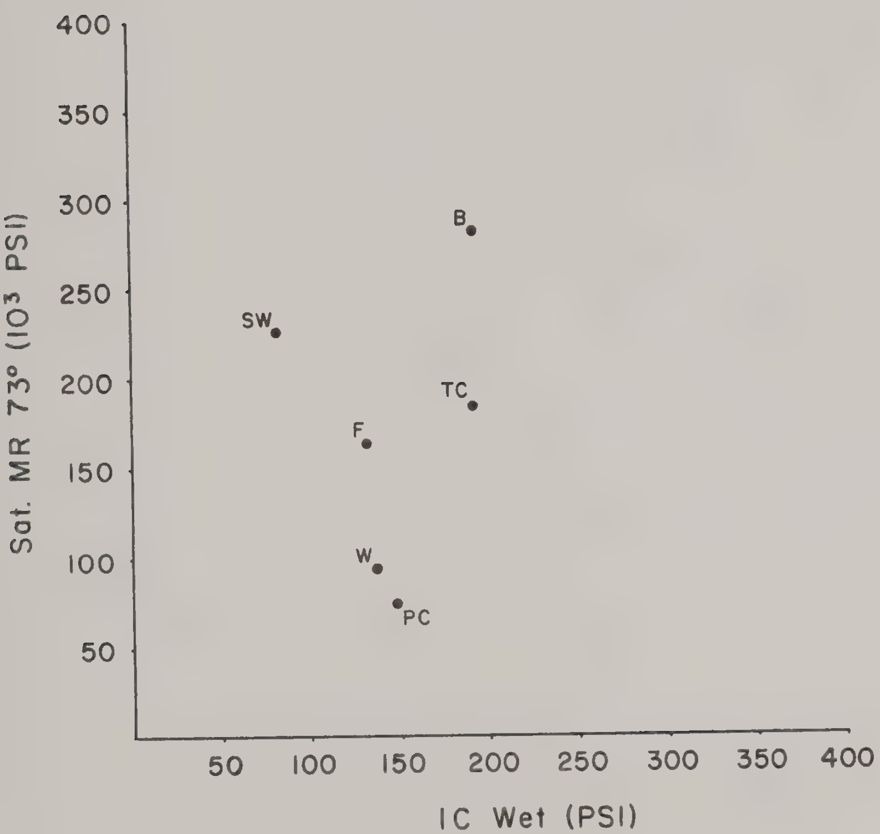


Dry Resilient Modulus Tests (73°)
vs. Dry Immersion Compression Tests

Figure 2

	y	x
	MR Sat. (73°)	IC Wet
W	94,210	137.7
B	281,314	191.4
PC	74,629	148.0
TC	185,326	191.1
SW	227,036	81.2
F	164,812	131.7

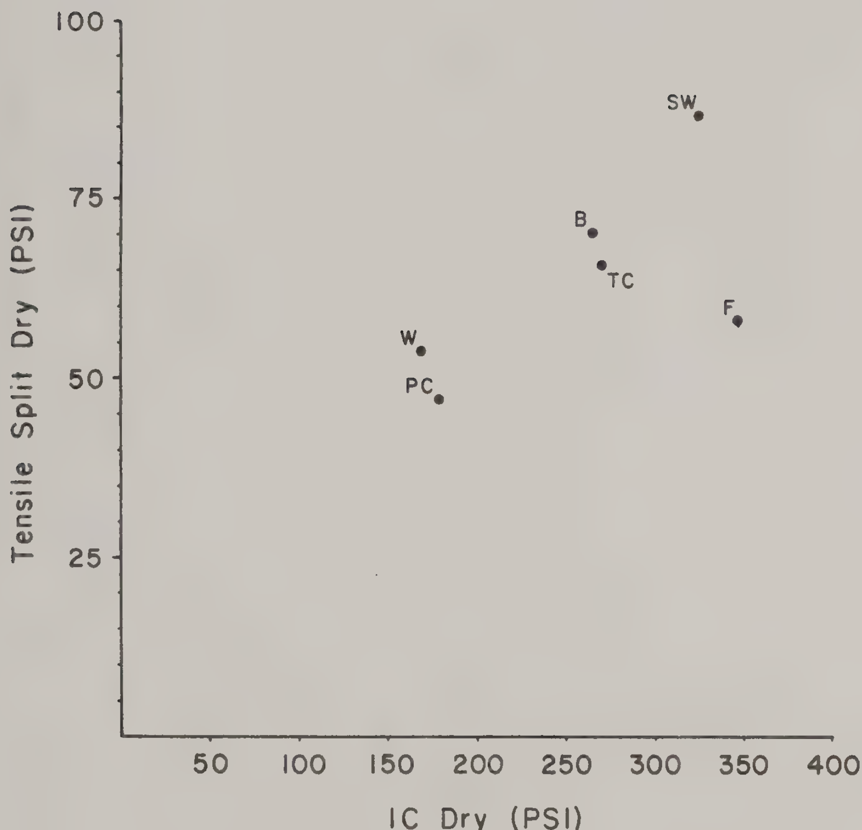
r = .16



Saturated Resilient Modulus Tests (73°)
vs. Wet Immersion Compression Tests

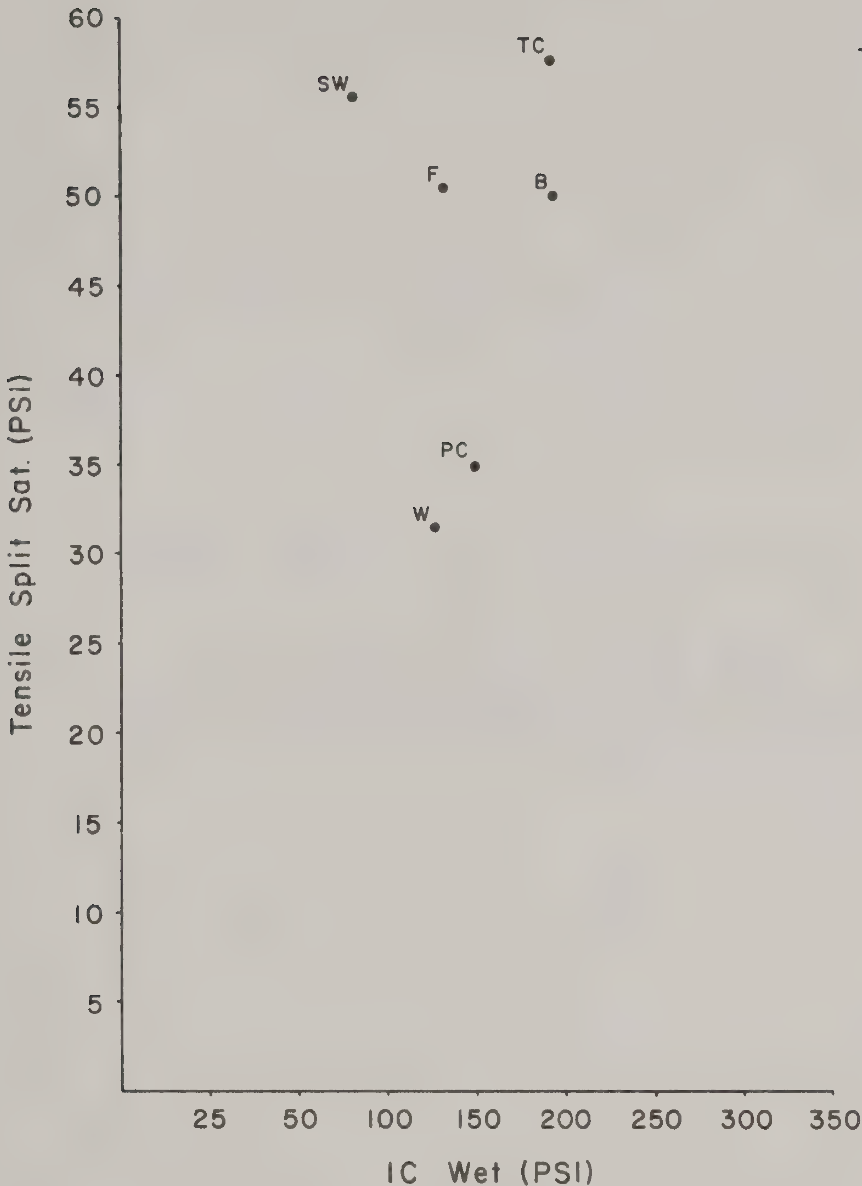
	y	x
	Dry Tensile Split	Dry IC
W	54.3	168.9
B	70.3	262.2
PC	47.4	179.0
TC	66.4	269.9
SW	87.8	324.7
F	57.9	346.2

r=.63



Dry Tensile Split Tests
vs. Dry Immersion Compression Tests

Figure 4

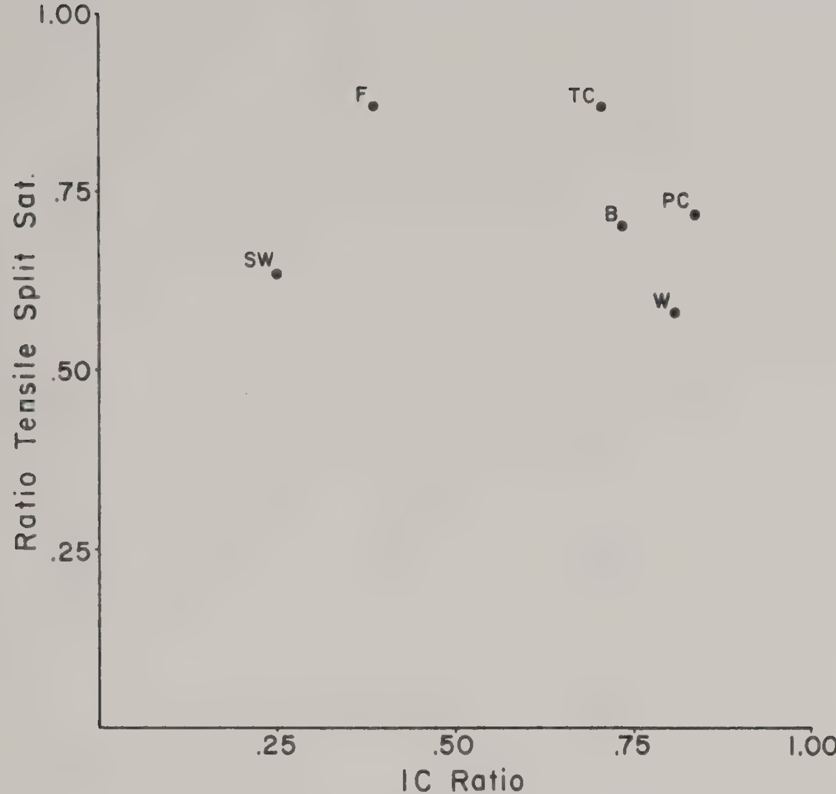


	y	x
	Sat Tensile Split	Wet IC
W	31.4	137.7
B	50.0	191.4
PC	34.9	148.0
TC	57.6	191.1
SW	55.7	81.2
F	50.5	131.7

r=.05

Saturated Tensile Split Tests
vs. Wet Immersion Compression Tests

Figure 5

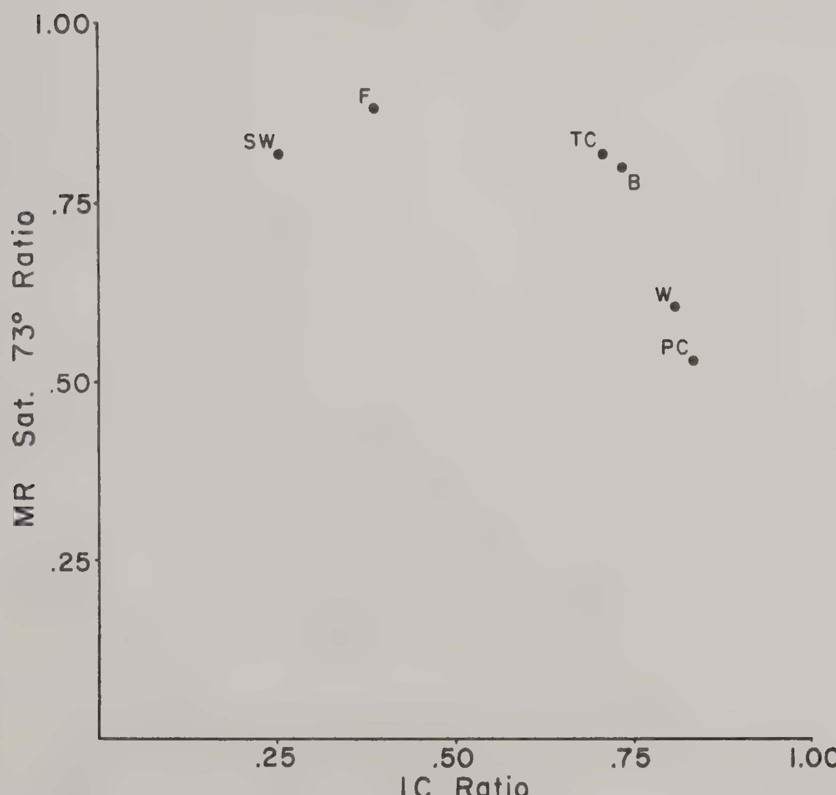


	y	x
	Ratio Sat Tensile Split	Ratio IC
W	.58	.815
B	.71	.73
PC	.73	.83
TC	.87	.71
SW	.63	.25
F	.87	.38

r = -.11

Saturated Tensile Split Ratio Tests
vs. Immersion Compression Ratio Tests

Figure 6

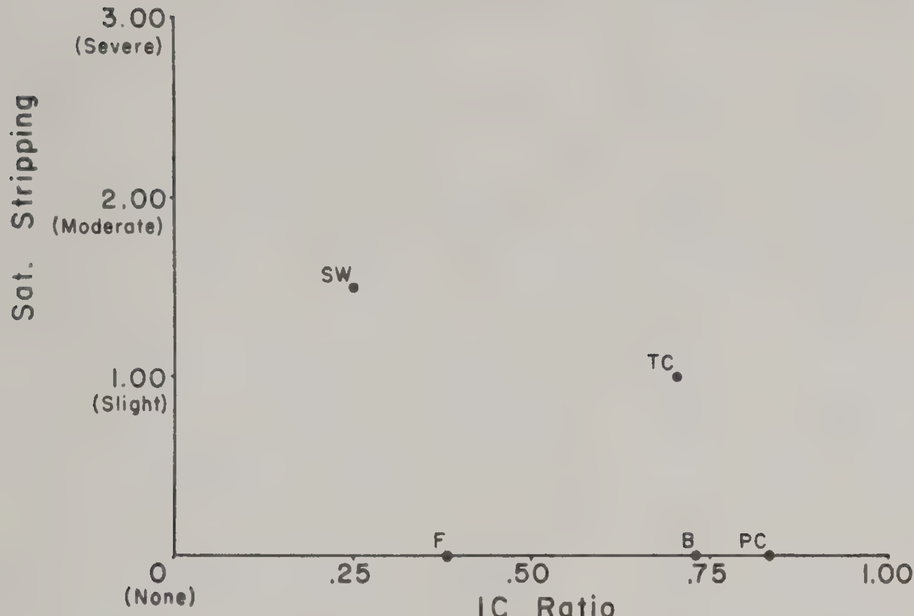


	y	x
	MR Ratio 73° Sat.	IC Ratio
W	.61	.815
B	.80	.73
PC	.53	.83
TC	.82	.71
SW	.82	.25
F	.88	.38

r = -.70

Saturated Resilient Modulus Ratio Tests (73°)
vs. Immersion Compression Ratio Tests

Figure 7

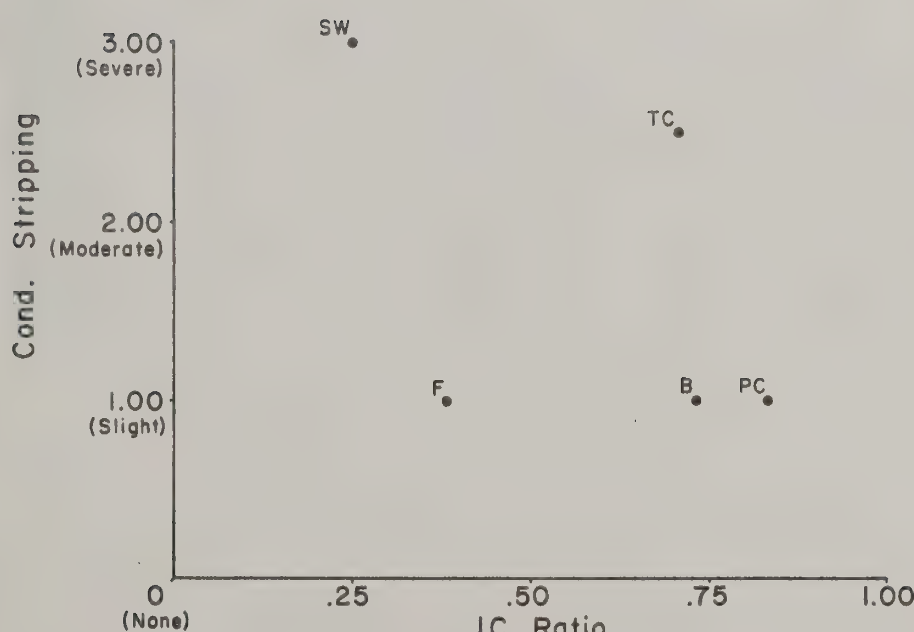


	y	x
	Sat. Stripping	IC Ratio
W	-	.815
B	0	.73
PC	0	.83
TC	1.0	.71
SW	1.5	.25
F	0	.38

r = -.52

Stripping Saturated Tests
vs. Immersion Compression Ratio Tests

Figure 8



	y	x
	Cond. Stripping	IC Ratio
W	-	.815
B	1.0	.73
PC	1.0	.83
TC	2.5	.71
SW	3.0	.25
F	1.0	.38

r = -.48

Stripping Conditioned Tests
vs Immersion Compression Ratio Tests

SIX SOURCE AVERAGES - NO ADDITIVES OR FILLERS

Test Cond	Wibaux	Billings	Prairie County	Toole County	Sieben-Wolf Creek	Fairfield
Mr 73° Dry	154,706	353,008	139,544	224,853	276,989	187,249
Mr 55° Dry	754,869	1,664,688	847,897	945,845	994,791	849,976
Tensile Dry	54.3	70.3	47.4	66.4	87.8	57.9
Mr 73° Sat	94,210	281,314	74,629	185,326	227,036	164,812
Mr 55° Sat	417,671	1,167,042	453,349	740,524	643,495	723,370
Tensile Sat	31.4	50.0	34.9	57.6	55.7	50.5
Mr Cond 73°	71,801	108,685	54,121	95,371	62,532	87,331
Mr Cond 55°	281,351	577,625	381,228	373,282	276,777	389,190
Tensile Cond	22.8	26.0	29.6	26.5	24.5	25.2
IC Dry	168.9	262.2	179.0	269.9	324.7	346.2
IC Wet	137.7	191.4	148	191.1	81.2	131.7
IC Ratio	.815	.73	.83	.71	.25	.38
Ratio Tensile Sat	.58	.71	.73	.87	.63	.87
Ratio Tensile Cond	.42	.37	.62	.40	.28	.45
Ratio 73° Sat Mr	.61	.80	.53	.82	.82	.88
Ratio 73° Cond Mr	.46	.31	.39	.42	.23	.47
Ratio 55° Sat Mr	.55	.70	.53	.78	.65	.85
Ratio 55° Cond Mr	.37	.35	.45	.39	.28	.46

SIX SOURCES AVERAGES WITH ADDITIVES OR FILLERS

Test Cond	Wibaux	Billings	Prairie County	Toole County	Sieben-Wolf Creek	Fairfield
Mr 73° Dry	205,896	514,422	250,440	257,996	397,484	270,147
Mr 55° Dry	929,324	1,328,763	1,242,894	958,734	1,151,581	945,085
Tensile Dry	44.5	57.2	56.6	62.1	87.7	65.9
Mr 73° Sat	156,960	412,686	177,024	228,879	258,539	239,136
Mr 55° Sat	751,642	1,234,517	1,001,037	869,641	699,895	787,532
Tensile Sat	37.3	60.9	53.9	58.0	60.4	58.2
Mr Cond 73°	164,331	107,343	127,487	175,902	261,439	160,518
Mr Cond 55°	774,351	508,335	763,926	665,606	738,540	616,872
Tensile Cond	34.9	24.0	44.5	42.6	51.9	39.6
IC Dry	223.2	348.2	179.1	279.5	333.4	414.6
IC Wet	188.6	264.2	170.3	224.5	186.2	304.8
IC Ratio	.85	.76	.95	.80	.56	.74
Ratio Tensile Sat	.84	1.06	.92	.93	.69	.88
Ratio Tensile Cond	.78	.42	.79	.68	.59	.60
Ratio 73° Sat Mr	.76	.80	.71	.89	.65	.88
Ratio 73° Cond Mr	.80	.21	.51	.68	.66	.59
Ratio 55° Sat Mr	.81	.93	.81	.91	.61	.83
Ratio 55° Cond Mr	.83	.38	.61	.69	.64	.65

Table 3

Correlation Coefficients

r		
.46	-	Dry MR 73° vs IC Dry Without Additives or Fillers
.49	-	Dry MR 73° vs IC Dry With Additives or Fillers
.16	-	Saturated MR 73° vs IC Wet Without Additives or Fillers
.51	-	Saturated MR 73° vs IC Wet With Additives or Fillers
.63	-	Dry Tensile Split vs IC Dry Without Additives or Fillers
.49	-	Dry Tensile Split vs IC Dry With Additives or Fillers
.05	-	Saturated Tensile Split vs IC Wet Without Additives or Fillers
.42	-	Saturated Tensile Split vs IC Wet With Additives or Fillers
.41	-	Dry MR 55° vs Tensile Split Dry Without Additives or Fillers
.15	-	Dry MR 55° vs Tensile Split Dry With Additives or Fillers
.60	-	Saturated vs Saturated Without Additives or Fillers
.33	-	Saturated vs Saturated With Additives or Fillers
-.11	-	Saturated Tensile Split vs IC Ratio Without Additives or Fillers
.55	-	Saturated Tensile Split vs IC Ratio With Additives or Fillers
.58	-	Conditioned Tensile Split vs IC Ratio Without Additives or Fillers
.59	-	Conditioned Tensile Split vs IC Ratio With Additives or Fillers
-.70	-	Saturated MR 73° Ratio vs IC Ratio Without Additives or Fillers
.21	-	Saturated MR 73° Ratio vs IC Ratio With Additives or Fillers
-.42	-	Saturated MR 55° Ratio vs IC Ratio Without Additives or Fillers
.58	-	Saturated MR 55° Ratio vs IC Ratio With Additives or Fillers
-.52	-	Stripping Saturated vs IC Ratio Without Additives or Fillers
-.75	-	Stripping Saturated vs IC Ratio With Additives or Fillers
-.48	-	Stripping Cond vs IC Ratio Without Additives or Fillers
-.61	-	Stripping Cond vs IC Ratio With Additives or Fillers

REFERENCES

1. Bruce, B. J. and Gustovich, R. D., "Predicting Moisture-Induced Damage to Asphalt Concrete Design Mixes, "Report FHWA MT 7926-02, Montana Department of Highways, June 30, 1978.

2. Lottman, R. P., Working Plan and Guidelines to Participating States for NCHRP 4-8(3)/1, Department of Civil Engineering, University of Idaho, June 10, 1975.

3. Lottman, R. P., "Predicting Moisture-Induced Damage to Asphalt Concrete," Final Report 4-8(3), University of Idaho, February 28, 1974.

4. Lottman, R. P., "The Moisture Mechanism That Causes Asphalt Stripping in Asphaltic Pavement Mixtures," Final Report Research Project R-47, University of Idaho, February 1971.

SLH/dk/205B